

LAMPAS:
OR,
DESCRIPTIONS
OF SOME
Mechanical Improvements
OF
Lamps & Waterpoises.
Together with some other
PHYSICAL and MECHANICAL
DISCOVERIES.

MADE BY
ROBERT HOOKE,
Fellow of the Royal Society.

LONDON,
*Printed for John Martyn, Printer to the Royal Society, at
the Bell in St. Paul's Church-yard. 1677.*

L A M P S:
OR, A
DESCRIPTION
OF SOME
Mechanical Improvements
OF
L A M P S.



The Hypothesis of Fire and Flame I did about eleven years since publish in the 16. Observation Pag. 103, 104, and 105. of my *Micrographia*, which hath so far obtained, that many Authors have since made use of it, and asserted it; nor have I yet met with one considerable objection against it. It shall not therefore be my business at present to discourse of, or farther explain that Theory, which any one upon a strict inquiry into, I question not, will find cause sufficient to confirm him in, but rather to mention some pleasant and beneficial uses thereof, and to hint some Mechanical contrivances for the supplying the *Pabulum* Oyl or Spirit by the same Degrees by which it is consumed in the flame of a Lamp, that great dissolvent.

I do not here design to shew a way how to make a perpetual Lamp, that being a Chimera which my Hypothesis of flame doth seem to destroy, for the dissolvend must in time be dissolved: But to shew a way how to make

B the

the Receptacle of a Lamp in such manner as that it shall continue to supply the *Pabulum* to the flame equally and for a very long time till it be all consumed. The consideration of which Problem first put me upon the enquiry after a counterpoise for Liquors or Fluids, which is also of very great use in Hydraulicks, as I shall hereafter have occasion to manifest.

This I can do by very many contrivances, depending from very differing Principles, all and every of which may be fitted so as to supply the Oyl or *Pabulum* of the Lamp in such quantity, and after such manner and proportion as shall be desired. I shall now omit all the other ways of performing this effect, though divers of them are as much or more considerable than any of these I here mention. And having promised in the 32 Page of my description of Helioscopes to publish a Counterpoise for Liquors, I shall only explain several ways by the help of these Counterpoises to do whatsoever can be required, as to the manner and quantity of supplying Oyl to the flame.

The chief design of the Counterpoise in this inquisition is to keep the Superficies of the Liquor (whether Oyl, Spirit of Wine, Oyl of *Turpentine*, or the like) whatever quantity there be in the Vessel, always to the same height, so that the said *Pabulum* shall always be equally distant from the bottom of the flame, and the Wick or flame being once placed at a convenient height or distance above the Superficies of the Oyl, shall not be deserted by the said Superficies till the whole quantity be consumed; but it is as easie to contrive it, to supply it by decreasing or increasing degrees, which are conveniences that none of all the Lamps I have ever yet met with have had, that was tolerable for use. The most ingenious is that which is commonly known by the name of *Cardans* Lamp, as being published and very probably invented by *Cardan*, which doth in some manner supply the wasting and decay of the Oyl caused by the flames Consumption. But then it is subject to a great many inconveniences,

veniences, which make it intollerable and difused : The first is, though it doth supply the defects of the Oyl to the Wick, yet it doth it not constantly and equally, but by starts and gluts; for after the receptacle by the Wick is filled, the Superficies of the Oyl continues to sink by degrees a considerable space below the flame, before there be any more supply added from the great Magazine or Repository, and till the Air can break in, (which it doth very unequally) so that there sometimes comes down so great a quantity that the receptacle is over-filled, and the flame extinguished, and these gluts are more unequal the bigger the Magazine be in proportion to the Receptacle by the flame, and the more the quantity of the Oyl be that is suspended, and the more the Air space be above the Oyl, and the more tenacious or sluggish the constitution of the Oyl is.

The second inconvenience of *Cardans* Lamp is that the Air is apt to rarifie it with heat, so as sometimes to drive down so much Oyl as to overflow the receptacle, and choak the flame.

The third Inconvenience is, that the Wick by the sinking of the oyl doth sooner decay the flame, being sometimes a little higher and sometimes lower upon the Wick; for if the Wick rise up into the hollow dead part of the Cone of the flame, the streams and coals of the Oyl will be so caked together as to dead the flame and much to diminish the light and heat thereof, whereas if the Wick be but short, and suffered only to go but a very little within the under-Superficies of the flame, it will not be so stopped and caked with those feculencies. The reason of which is evident, for the flame, as I formerly proved, being nothing but the parts of the Oyl rarified and raised by heat into the form of a vapour, smoak, or steam, the free Air that incompasseth this steam keepeth it into a Cylindrical form, and by its dissolving property preyeth upon or dissolveth those parts of it that are outwards and next to the Air, so as by the said dissolution it continueth the heat, and produceth the light which we observe; but

those parts of the body of steams that rise from the Wick, which are in the middle, and not contiguous to the outward Air, are not dissolved or turned into shining flame by the Air till they rise towards the top of the Cone of flame where the free Air can come to reach, and so to dissolve them, and thence gathering about the Wick in the Center of the Cone of flame they choak, clog, and quite stifle it that the flame will quickly go out. That this is so, any one may easily find if he examine the flame of a Lamp or Candle by the help of a piece of glass. For by the transparency thereof he will plainly perceive that all the middle of the Cone of flame neither shines nor burns but only the outward Superficies thereof that is contiguous to the free and unsatiated Air, and that the middle parts may be collected in the form of Soot, or very fine powdered coal dust.

Take then a piece of Glass, whether Window-Glass, Looking-glass Plate, or the side of a Viol, it matters not, or, which is best of all, a thin Plate of *Selenitis* or *Muscovia* Talk, and hold it Horizontally in the middle of the flame, so as to cut off the top or upper part of the Cone thereof, then presently, before it be choaked with soot, look down upon it, and you shall plainly see that all the middle parts of the Flame and the Wick have no shining power or light at all; nor are they dissolved by the Air, but remain in the form of Soot, but that only the Superficies or outside of the said Cone doth burn, shine, and consume into and mix with the ambient Air.

In the same manner, if you hold the Glass or *Selenitis* perpendicularly, and apply the side of it so as to cut the flame *per axin coni*, that the Air cannot come to one side thereof, you may plainly perceive that the shining part of the flame is only that which is contiguous to, and preyed upon by the free and unsatiated Air, and that where that Air cannot come free without being glutted and satiated in its way, there neither the consumption of the Oyl, nor the heat and light of the flame is produced, but only a sooty, choaking, and stifling substance.

To,

To make then the reason of the Phenomena observable about the lasting or stifling of the flame of a Lamp the more clear and easie to be understood and comprehended, give me leave to explain the manner of its production and continuation by a Scheme, delineation, and description thereof.

Let A A then in the second Table represent a body of Oyl, or any other combustibile fluid substance, the Superficies whereof B B is Horizontal, and pretty near plain. [I say, pretty near, because it is always either Concave, or Convex, more or less according to several circumstances; to wit, the capacity and the nature of the Vessel E E, in which it is contained; for if the Vessel be small, and that the Oyl hath a greater congruity with it than the Air, the Superficies of the Oyl will be very much concavated especially towards the sides of the Vessel as at C C; but if the Vessel be incongruous to Oyl, the Superficies will be Convex as at D D, the reason of which I have long since explained in another place.]

Let F F then in the third figure represent the Wick, which consists of a great number of very fine Cylinders or hairs of Cotton fff-twisted and laid very close together, into, and between which the Oyl (having a very great congruity therewith) doth readily insinuate it self and adhere, and is by the pressure of the Air (much greater without than between those Cylinders or hairs) forced up to a considerable height between them, (as to the height of an inch and half, or two Inches) and if by any means the Oyl be taken out at the top thereof, the remaining part of the Oyl in the Vessel will ascend to supply the vacancy of the part drawn off, which is evident in Filtration. About the sides of this Wick the Oyl will be sure to ascend, and the Superficies thereof will be concavated as at G G, because unless there be a congruity between the Oyl and the Wick there will be no ascent of the Oyl therein, and therefore that substance that the Oyl doth not readily adhere to cannot be a fit material for that purpose.

Now.

Now to this Wick thus filled with Oyl apply the flame of a Lamp or Candle, or any other substance extremely hot, as a glowing piece of Iron, Copper, or the like, and by this means the parts of the Oyl in the Wick will be very much heated, and expand themselves in vapours into the contiguous Air by the steams $h h h h h$, and fill all the Ambient space of the Air $H H$ therewith, which vapours being very much rarified, and consequently lighter than the encompassing Air, are by the greater gravity and pressure thereof carried upwards by the Curve Lines $h i k$. These at first gush out of the Wick at Right Angles, but by the protrusion of the Air are quickly turned into a kind of Parabolick Curve $h i k$. The motion of the Particles in which is swiftest in $k k$, that is to a certain degree of Altitude. The motion of ascent increasing somewhat after the nature of the motion of descent in heavy bodies, I say somewhat in that nature, for if the ascending bodies were uniformly lighter than the Ambient they would be the same, but because the rarefaction and nature of them is varied by Circumstances, therefore it hath but part of that Analogy.

To proceed then with the Explication: I say, these steams of the Oyl thus ascending, if they are heated to a sufficient degree of heat are preyed upon, and dissolved or burned by the Ambient Air; which dissolution hath this effect, first, that it produceth light; next, that it produceth heat enough to make the succeeding parts of the steams that rush out of the Wick and follow after it to be sufficiently heated for dissolution by the Air, the heat of which produceth the same operation upon a third, and that upon a fourth, and that upon a fifth, and so successively so long as there are steams of Oyl to be dissolved, and plenty of fresh and unsatiated Air to dissolve. The action also of this dissolution causeth heat sufficient to raise up the succeeding parts of the Oyl into the Wick, and expand them into vapours, and so to make them fit to be further heated and dissolved. It is further observable in the flame of a Lamp, that those vapours
that

that issue out of the Wick are by degrees dissolved, and not all in a moment, for the parts of the flame that are lowermost about H have a kind of faint blew light until they come to I, where they seem to have their brightest and clearest light and heat, the said vapours not being heated to that degree at their first breaking out that they afterwards acquire by the farther action of the Air upon them. At I they seem to be in their highest degree of dissolution, and from thence upwards are made one with the dissolving Air, so that they are not but by other means discernable to the eye of the observer; so that the shining part of this Conical shaped space of the flame is only the outside of the Cone, it being that part where the Ambient Air preys upon the ascending eruptions of the Oyl, namely, where the Chain of small Circles intercept the Curve lines of the motion of the ascending eruptions.

This Figure and shape of the flame and vapours may be plainly seen by the help of a Metalline Concave placed at a certain distance and Position, and also by observing the shadow of the Candle cast by the beams of the Sun upon a sheet of white Paper, or white Wall, but that way of a Concave *speculum* is incomparably beyond it, because it doth so very plainly shew the form and manner of the steams rising above *iiii*, as about *kkkk*, &c.

The Air after it hath performed the action of Dissolution, and is satiated and incorporated with the parts of the Oyl at *iii*, ascend by *kkk*, but shine not. All the steams or eruption of the vapours of the Oyl out of the Wick *fff* shine not between the Wick *ff* and *ii*, but begin to be dissolved, and to shine as they approach the fresh Air at *ii*, where the dissolution is completed.

The upper parts of the flame shine more than the lower, the parts having been heated to a much greater degree by the longer space of passage they have had through the hot Concave part of the flame, and contiguous or very near to the glowing sides thereof at *iii*.

All the under parts of the Wick, neither shine nor burn,

burn, but are as it were char'd by the extremity of the heat of the Conical Superficies of the flame, they are defended from burning at the bottom by the fresh access of new Oyl from the Vessel underneath; and the middle parts are defended from burning or shining by reason the Air cannot approach them before it be satiated at the Conical Superficies i i i by the dissolution of the steams of the Oyl it there meeteth with. But the upper parts of the Wick do burn and shine, if they be high enough, into the smaller part of the Cone of flame that the Air before it be satiated can reach at them. And if any part of the Wick fall into the said Conical and shining Superficies of the flame, it doth both shine and consume, and suffers the same dissolution into the Air as the steams of the Oyl, and if any part of this Wick be without this Conical Superficies at i i i, it is presently consumed and reduced to Ashes; as by many experiments differing ways made is very plainly visible.

This plainly gives the cause why knots and Tophus's do as it were grow to the Wick of the Lamp like so many Mushrooms on a rotten Tree, which as soon as they are removed out of the middle and dead part of the flame are immediately consumed by, and dissolved into the Air, and shine like a coal of fire, as being indeed nothing else.

Hence we may give a plain Reason why upon applying any cool Superficies very low into the flame of a Lamp, there is immediately condensed upon it a great quantity of soot, namely, that the middle parts of the Cone of flame, being nothing but a great number of oily steams ascending, are not fired nor consumed by the Air, till they can come to be wrought upon by the free and unsatiated Air. Now if the Air be so intercepted that it cannot come at them, and the steams be cooled by the plates coldness that the Air is not able to prey upon or dissolve them for want of a preparatory heat sufficient, they must remain in the form of burnt Oyl, or Lamp-black.

I have been somewhat the longer and more particular
in

in this description and explanation of my Theory of the flame of a Lamp or Candle, that so the Reader understanding the nature and causes thereof the more fully and plainly, he may the easier discover the inconveniences that may occur in the burning, heating, shining, duration, &c. thereof, and the sooner and more readily and scientifically find a cure and prevention of those inconveniences, which he that is ignorant of can but hoodwinked grope after, and at best can but hope possibly after long puzzling himself in vain attempts and blind trials, nothing to the purpose, he may at length stumble upon that which had he been inlightned by the true Theory, he would have readily gone to at the first glance.

I could have further expatiated into the contemplation of this most admirable Phenomenon of flame, producing heat and light, the two most spirituous and most potent Agents in Nature, and the ways of Intending and Diminishing them, and the uses that may be made of them, but that it is not my present design to annex a discourse on those subjects, which doth more properly belong to another Lecture I shall shortly publish. I shall therefore at present proceed only to shew some Mechanical contrivances for counterpoising Liquors in Vessels, so as to keep them running or supplying a stream always with equal swiftness, whatever quantity there be of the said Fluid; which as they are very convenient for perfecting Lamps for divers uses, which they could not otherwise perform, so in Hydraulick they are of most admirable benefit for divers effects, hardly to be performed without them, as I shall hereafter manifest. But first, I will explain some few ways by which more conveniences may be obtained, and more inconveniences prevented in the use of Lamps for Chymical, Mechanical, and Philosophical uses than by this way of *Cardan*, or any other I have met with: For this I look upon as one of the Tools to be made use of in the Work-house or Elaboratory of Nature, without a good Apparatus of which, be the Workman otherwise

never so well accomplished, he will never be able to produce any very considerable effect; and with them, even a Bungler otherwise, will, if well furnished, do wonders to such as know not the means by which they are done.

It may possibly seem very strange to some to hear, that by the flame of a Lamp Plants may be made to grow, bear Leaves, blow Flowers, ripen Seeds; that the Eggs of Fowls and Insects may be hatched, and brought to life and perfection; that Metals, even the hardest, Glass, Stones, &c. may be almost in a moment melted, softened, liquified, hardened, &c. that thousands of separations of conjoyned and naturally united bodies may be effected, and they reserved distinct; and as many other bodies, naturally distinct, and very differing, may be united and compounded into Homogeneous mixtures, some scarce separable afterwards; that Glass may be shaped and moulded like Wax; that almost all the sensible qualities of bodies may be increased, diminished, annihilated, and created; and some also of the qualities insensible (otherwise than by the effects;) and yet even these, and many more, may be effected by this Tool or Instrument, if rightly used, as I could manifest if I had now time. But I shall not here any further expatiate on it; possibly I may hereafter but at present I shall only proceed to the description of one sort of those Instruments which serve to supply the Oyl or *Pabulum* of a Lamp conveniently by any degrees, and in what quantity is desired. This sort doth depend upon some contrivance of Counterpoises for the Liquor in the Receptacle that is to feed the Lamp, and may be made use of in Hydraulicks as well as Lamps to feed and continue any running stream any time desired.

These Counterpoises then of Fluids might be made to feed the flame of a Lamp equally for any time assigned, and consequently would make a kind of Perpetual Lamp, but the *Pabulum* it self will be some ways or other unapt for such an effect; as Oyl hath a foulness whereby the Wick

Wick is choaked or stopped, so as that it will no longer ascend in it ; Spirit of Wine will in length of time evaporate and lose much of its nature ; and other Oyls have their several defects which make them incapable of continuing the flame very long. But there are none of these that I have met with but may being great measure avoided by the help of some Chymical or Mechanical contrivances, some instances whereof I shall hereafter give, which the Theory of Fire and Flame doth readily hint.

The first way then I shall now describe is by a round Box, the inward Cavity of which is divided by a Diaphragm into two equal parts, and fitted with a proper Counterpoise, the Axis of whose motion lieth Horizontally. The contrivance of which will be more plainly understood by the Delineation thereof in the first place, where the second Figure represents the whole Instrument, with its Globe, Frame, Pedestal, Socket, and lighted Lamp.

A represents the Pedestal or foot upon which the Instrument stands, which may be made of Silver, Brass, Wood, or the like. BCDEF, the Frame fastned to the Pedestal, and shaped in the form of a Snake, perforated at B and D to receive the Pivots or Gudgeons of the Lamp G H, and hollow from E to F to serve to convey the Oyl or Spirit of Wine from the end of the hollow Gudgeon H to the Wick I, to feed the Flame K ; the hole at E to receive the end of the hollow Gudgeon ; H is made a little tapering, and the end of the Gudgeon H is ground fit into it, so as to turn easily, and yet so true, as not to let any Oyl there leak out, the said Gudgeon being kept close home by the springing of the Arm B ; the Superficies of the Oyl or Spirit for the *Pabulum* is always kept by the motion of the said Globe upon its Axis G H, exactly in the Line L M, untill it be all consumed ; which how it is done will be better conceived by shewing the contrivance of the inside of the aforesaid Globe, how the same is divided, how filled, and how counterpoised.

Suppose then the aforesaid Globe cut in sunder by the middle Line or Circle NO , and discovering the Inside or Cavity thereof to be represented in the first Figure, where $PAHRZP$ represents the aforesaid Circle, or half shell of the Globe; O represents the middle of the hollow Gudgeon H , which is the Pole or Axis about which the said Globe doth move. HOZ represents the Horizontal Line or Plain passing through the aforesaid Axis; PR the Perpendicular to that Plain. Let HZ then represent a Diaphragm or Partition of the same material with the Globe, by which the Concavity thereof is divided into an upper Hemisphere $HPZO H$, and into an under Hemisphere $HRZO H$. Let the under Hemisphere be filled with Oyl, Spirit of Wine, &c. or the like fit material for a Lamp to burn; and let the upper part be filled with some material of half the weight of the Oyl, Spirit, or other material, or because that will be somewhat difficult to do, let there be a counterpoise of Lead or other ponderous matter fixed somewhere in the Line PO , so that the said upper Hemisphere shall have half the gravity of the under Hemisphere upon the Center of motion O . I say, whatever quantity of the Fluid *Pabulum* is in the Cavity of the said under Hemisphere, the Superficies thereof shall always be in the Horizontal Line or Plain OZ , the counterpoised upper Hemisphere keeping it always up to that height. For instance, supposing the said Hemisphere full, there is no doubt but that the under Hemisphere being double the weight of the uppermost will be lowermost, and that Horizontal Line will lie Horizontally, since it is evident, that the Center of gravity of the whole will be below the Center of motion O , and somewhere in the Line OR , which is Perpendicular to the aforesaid Plain. Next, suppose so much of the aforesaid Liquid *Pabulum* consumed as to leave enough only to fill the space $GOZBRC$, and the Diaphragm be moved from its Horizontal Position HZ , and placed in the Oblique Position COD . I say, the said upper Hemisphere

CHAPDOC shall exactly counterpoise the said under Hemisphere CRBZDOC, so as the Superficies of Liquor shall be in the Horizontal Plain OZ. Make AP equal to PD, and draw the Line AOB through the Center O, it is manifest then that the Wedge COR of the Liquor doth counterpoise the Wedge ROB on the other side the Perpendicular, and that the Wedge POD of the upper Hemisphere doth counterpoise the Wedge POA on the other side of the Perpendicular, so that neither of these have any prepollency to move the Globe out of this Posture. Next, it is plain that the Wedge BOZ of the Liquor will be counterpoised by the Wedge AOC, which is double the bigness of BOZ, and consequently of equal weight; the parts of the upper Hemisphere being put of half the gravity or weight of the under Hemisphere.

Next, suppose half the Oyl be consumed, and there be only left enough to fill the quadrantal Wedge ZOR, I say, the Superficies thereof shall be in the Horizontal Line OZ; for since the upper Hemisphere is half the weight of the under, the two quadrantal Wedges POH and HOR must necessarily counterpoise the quadrantal Wedge ROZ of the Oyl.

Thirdly, Suppose that more than half the said Oyl or liquid *Pabulum* be consumed, and that there be only left enough to fill the Wedge BOZ, I say, the counterpoising upper Hemisphere now made the under, and placed in the Position AHC RBOA shall exactly counterpoise the said Wedge of Liquor, so as that the Superficies thereof shall be in the Line OZ; for the Wedge ROB of the aforesaid upper Hemisphere doth counterpoise the Wedge COR on the other side of the Perpendicular, and the double Wedge AOH and HOC will counterpoise the Wedge BOZ.

Nor can the Superficies of the Liquor be any whit higher or lower than the Line OZ, for if it be any whit higher as at EF, the Liquor must necessarily overpoise the aforesaid Wedge AOC, by all the weight of the
Liquor :

Liquor contained in FGOZF. And if it be any whit lower as at IK, the Wedge KIB must be too light for the counterpoising Wedge AOC by the weight of the Liquor contained in the space ZOTKZ, since I just now shewed that AOC did just counterpoise ZOB, which was the thing to be proved.

Now though in this Instance I have chosen to explicate I have made choice of a Globe, yet that form is not necessary, but it may be made of any Figure whatsoever that is turned upon an Axis or Poles, so as wheresoever the said Figure be cut by a Plain to which the Axis is Perpendicular, the Superficies of the said Figure shall describe a Circle, the Center whereof is in the said Axis, whiether the said Figure be a Cylinder Cone, or any other Conoeidical, mixt, or otherwise, regular, or irregular figure. Such as the Figures ABCDEFG, which represent the Section of the said Vessel through the Axis.

The second way for the poyling the Liquor, and keeping the Superficies thereof always to an equal height, is this :

Make a Concave Receptacle for the Oyl or Liquor of a Hemispherical, Semicylindrical, Semiconical, or of any other half-round hollow Figure, where the turned Figure is cut in two parts *per Axin*, and whereof the Axis is placed Horizontal, and the plain Section *per Axin* likewise Horizontally, so as it may be filled with any Liquor up to that Plain; and that the Liquor may not be apt to dash, be shaken, or filter over, it will be convenient to extend the brims of that Receptacle somewhat above the half-Round, that there may be about half or three quarters of an Inch of space above the Superficies of the Oyl vacant or empty. And that upon whatever Plain the foot stand, the Plain *per Axin* may stand Horizontal, it will be good to suspend the Receptacle in the same manner as a Sea-mans Compass is suspended, within a frame :

Fix

Fix this Receptacle, or the Frame that is to keep the Receptacle, Horizontal upon a convenient Pedestal; and fit within the Hollow or Concavity of the Receptacle a half-round solid poise, turned of the same form with the hollow of the Receptacle, and cut exactly through the Axis in two equal parts. Let this solid poise be made exactly half the weight of the Liquor that is to be poised, and fit to it two Pivots or Pins at each end of the Axis, which may be exactly in the Poles of the half-Round, and fit to those Pins make two holes in the Centers of the Ends of the Concave Receptacle, in which the Pins may freely move, and suffer the half-Round poise to move round within the hollow of the Receptacle, according as the quantity of the Oyl or Liquor is increased or diminished. Fit to this Receptacle a neck and socket fit for the Wick and flame of the Lamp, and the same operation will be performed by this as by the first contrivance; to wit, the Oyl will be kept always to the same height in the Receptacle.

This will be easier understood by explaining a Designation thereof which is shadowed forth in the fourth Figure: Where

A A A represents a Pedestal, which may be made with three claws or toes to make it stand the steadier and even upon any Plain or Table.

B B represent one of the Semicircular Arms that are fix'd to the top of the Pedestal, this hath two holes in it at the ends or extremities, as at C is one, the other hole being in the other arm which goes behind the Globe, and therefore cannot be seen, is supposed to be Diametrically opposite to this at C. These two holes are the Center holes in which two small Pins or Centers, fastned into two opposite points of the Hoop or Frame are made fit to move, by which means the said Hoop is preserved in an horizontal Position.

D D is this Hoop or Frame, which is made to encompass the Vessel or Receptacle of the Oyl, and is shaped exactly like it. This is made strong enough of Brass, Iron,

Iron, Silver, or other material to bear the Receptacle, Poise and Oyl without bending, and hath, as I said before, two Pins or Gudgeons at C, and opposite to it Diametrically, or Semicircularly, upon which the said Hoop always hangeth Horizontally. It hath also on each side in the middle between the aforesaid Pivots, two Centers as at F and E to receive the ends of the Axis of the Receptacle appearing at F and E, by which the said Receptacle is always free to hang plumb or in its Perpendicularity, so as that the upper edge thereof at F F will always lie Horizontally.

One of these Pivots, namely, that on the Right hand is the Pipe to convey the Oyl to the Socket of the Lamp I, in which is fitted a Wick of Cotton to serve for the flame, K G G represents the Vessel or Receptacle of Oyl, which is here described Hemispherical, that being the most capacious uniform Figure, but may be of any other, qualified as those I mentioned in the first contrivance. The Brims of this are extended somewhat higher than a Semicircle, namely, to F F, to keep the Oyl from flashing or filtering over. This is always kept full with Oyl or other Liquor to the Horizontal prick'd Line L L, which passeth through the Center or Axis of its Cavity by the Counterpoise moved on the Center C.

H H H represents that Counterpoise which is made exactly half the weight of the Oyl or Liquor, and the Center of gravity of it must be somewhere in the Line M M; and it ought to be fitted as exactly into the hollow of the Receptacle as it is possible, that there may be left as little space as may be between its convex sides and the Concave of the Receptacle, but yet so much must be left that it may move very freely upon its Center C a whole Semicircle. This done, and the Receptacle being filled with Oyl, the same effect will follow as in the first contrivance, and the Demonstration of it being much the same, I shall not now spend time to explain it. But rather proceed to the description of a third way of keeping the Liquor counterpoised to the same level.

The

The third way then is :

Take any round Vessel, whose Concavity and Convexity is turned upon an Axis, and suspend that Vessel upon two small Pivots (but yet big enough to bear the said Vessel filled with Oyl, &c.) fastned in the Poles of that Axis; and leave or cut open a sixth part more or less as you please of the side thereof, that thereby any thing may be put into or taken out of the Cavity of the Vessel; then poise the Vessel exactly on those Centers, that no side be heavier than the other; then fit into it a float of Brasse, Silver, Tin, Lead, &c. Convex on the under side, so as just to fill to the Cavity of the Vessel. And on the upper side, Plain, or Convex, or any other convenient Figure, it matters not much. Make this float as heavy as you can at the bottom, and as light as may be at the top, but yet of such weight as may well float upon the top of the Oyl, &c. Let one end of this be fastned by a wire or string, so as that end thereof may always touch that point of the Concave of the Vessel to which it is tied, and that the rest thereof may turn and follow the sinking of the Oyl; and through the end of it, near the place where it is fastned, let a Pipe go through it to receive the Wick, which Pipe hath no communication with the Cavity of the hollow float. This done, fill the Vessel as full as convenient with Oyl, and light the Wick, and you shall find that as the fire consumeth the Oyl, the Vessel will turn upon its Poles and keep the Superficies of the Oyl always at the same distance from the flame that it was put at at first till the whole be consumed.

This will be made more conceivable by a figure and explanation thereof, which therefore take as follows in the fifth figure.

A C B B represents a hollow Vessel, the Cavity whereof is very exactly turned upon an Axis whose Poles are in P, the space between A and B in the side thereof is left open into the Cavity of it. This Vessel is suspended

D upon

upon its Poles at P, so as to be free to move round upon them, and exactly poised as no one side thereof be heavier than another. To the hollow of this Vessel is fitted a float D of Brass, Latton, Silver, Lead, &c. whose underside is made of a Convexity just fit for the Concavity of the Vessel, as may be seen at K D I, and the upper straight or Plain. Let this float be made somewhat lighter than the Oyl or Liquor on which it is to swim, so that a part thereof may float above the Superficies thereof. Let one end thereof E be fastned to the side of the Vessel a little below the Brim B; through the end of this float is put a Pipe and Wick h, for the flame i, then pouring in Oyl by the open side A Q B, fill the same till it carry the float up to touch the hollow of the Vessel; then light the Wick, and you will find that the Lamp will consume the Oyl; and this contrivance will continually supply it till the whole be consumed, and the Poise be moved to touch the Concave of the aforesaid Vessel; for when the Vessel is filled up to fg, the float D will touch at O and E, and the Cavity above fg being empty, the Vessel will be as is described in the Figure, the open part A B being upwards. And as the flame consumeth the Oyl, the side of the Vessel B will descend downward towards B 1; and so by B 1, B 2, B 3, to B 4, where the whole quantity of Oyl will be consumed, and the bottom of the float will touch the hollow side of the Vessel; in all which gradual waisting of the Oyl the Superficies thereof will lie at the same distance below the upper side of the float D that it had at first, and consequently at the same distance from the bottom of the flame. The reason of all which will be very easie to be understood by any one that shall seriously on this Delineation consider that the float D must necessitate the Vessel A C B to move on its Axis B according as its Oyl waists, because one end thereof E being fastned to the brim of the Vessel B, the other end O being loose will as the Oyl waists descend towards N, whence the end E must hang heavier on the brim B, and consequently must move it down towards B, till the upper side

side fg of the float be reduced to a Parallelism with the Superficies of the remaining Oyl, and the end E have no gravitation on the brim B, which motion will be continued as the Oyl wafts, and the brim B will be moved downwards by the points B 1, B 2, B 3, to B 4. I shall not therefore spend any more time in the Geometrical demonstration thereof, but proceed to explain a fourth way by which the Flame and Superficies of the Oyl keep always at the distance they were first put at.

The Fourth way then is, the making the Socket of the Wick to swim upon the top of the Oyl, so that the Socket may sink as well as the Oyl, by reason it is sustained by that, and by that only. The Vessel or Receptacle is generally made of Glass, and it is best of a Hemispherical Figure, the light casting it self through the body of the Oyl as well as of the Glass. This is so plain and obvious, and so commonly used and practised, that I need not spend more time in the explanation or demonstration thereof, but proceed to describe a Fifth way.

The Fifth way then is much upon the same principle with the Fourth, but avoids several inconveniences to which that is subject: For whereas the Flame in the Fourth is necessitated to be within the capacity or the Receptacle in this Fifth, it may be at any distance, and so is made much more convenient to be come at, and to be dressed and trimmed. Take then a Vessel of Glass, Cylindrical is best, as a Glass Bottle, and fit to it a Siphon, long enough to draw the Oyl from the bottom of the said Vessel, make the one end of this Siphon extend at what distance you think convenient for the placing the flame of the Lamp, and so order it that it may always draw from the Receptacle by its arms to feed the flame, which it will do if the end of the Siphon be made where the Socket of the Lamp is placed to return or bend upwards again. So that the Plain of the upper Superficies of the Oyl may cut that end of the Siphon where the flame is

between the top of the mouth of it next the Socket and the return thereof upwards; then by a counterpoise so suspend this Siphon that it may follow the Oyl as it wafts, and fit into the return of the Siphon a Socket and Wick for the flame to be continued. A contrivance somewhat of this kind you have in divers Authors, and therefore I shall spend less time in the description thereof. Let A A A A in the Sixth Figure then represent a large Cylindrical Vial of Glass through the mouth B of which the Cavity thereof may be filled with Oyl, and also the end D and float C of a convenient Siphon may be put in. This Siphon D D D P G must be made long enough that the float C may reach the bottom of the Vessel when the Oyl is spent, and the other end thereof must be so curved that the knee of the Siphon P may be below the Superficies of the Oyl E F, and yet that the Socket H made for holding the Wick for the flame I may be somewhat above it, this Siphon D D D P G with its Socket and float should be so counterpoised with a weight M, hung over a Pulley K, by a string L, that the float may not sink deep into the Surface of the Liquor, but swim as it were at the top. This done, if the Wick I be lighted, the Surface of the Oyl will be kept always at the same distance below the flame that it was first put at.

In the first, third, fourth, and fifth ways the flame of the Lamp descends equal spaces with the Superficies of the Oyl in the Vessel, and therefore though for some uses it be very convenient, as in annealings, where things are to be cooled by degrees, yet for many other it is not; Especially in Lamp Furnaces, where the same heat is to be continued, and in some cases gradually increased. For such cases therefore the first and second ways will be very convenient. In some other cases the sixth and seventh ways, which do much the same thing.

The sixth way then is this; Through an arm or Siphon (like the Branch of a Lamp hung against a Wall) fixed in any convenient place, the Oyl from the Receptacle is continually

continually and equally supplied to the flame of the Lamp by the raising of the Receptacle as fast as the Oyl waists, so as to keep the Superficies of the Oyl alway in the same Horizontal Plain. The Receptacle is raised by a Counterpoise hung upon a Fusely, which Fusely is a part of an Archimedean Spiral.

Let C C then in the seventh Figure represent the Receptacle for the Oyl, being a Cylindrical or Prismatical Vessel; of what Bigness or Length you please; to this by two Ears at L L fasten two Lines or Ropes K K, the ends of both which are fastned to the Wheel or Pulley G; though one of them do run over the Pulley F. Fit into this Receptacle is made a Cylindrical or Prismatical Plug A A, which is fixed in some convenient place, so as not to rise or sink, and through the middle thereof passeth a Siphon B B B, the one end whereof extended like the branch of a Candle or Lamp sustains the Socket D for the Flame E, which is fed with Oyl through the Siphon B B B by the rising Receptacle C C.

To the side of the Pulley G is fastned a Fusely H, made with very great care of one Revolution of an Archimedean Spiral, not beginning from the Center, but from some convenient distance from it, where the weight I hanging, may just counterpoise the Receptacle C C, when quite empty of Oyl, the other hanging counterpoise (Tangent to the largest part of this Spiral) must be so far distant from the Center of the Wheel G, that the same weight I may just counterpoise the said Receptacle filled top-full of Oyl, and the Fusely must be filed true to a Spiral, drawn with great care of one Revolution between those two points. I say here of one Revolution, because I have supposed the Wheel or Pulley G big enough, by one Revolution of it to draw up the Receptacle the whole space it is to be raised; for if the said Pulley be so small as to require two, three; four; or more Revolutions, then must the piece of the Spiral between those points be drawn of two, three, four; or more Revolutions proportionably, which
being;

being very Artificially and Mechanically performed, the Receptacle C C will be raised by the same Degrees by which the Oyl is consumed at E, and the upper Superficies thereof shall always be in the same Horizontal Line M M. The Geometrical and Mechanical Reason of which being so very plain, I hope I shall not need to spend any more time in the explication thereof than only to say, that by means of the Archimedean Spiral-Fusey the Power of the weight I upon the Pulley G decreaseth in the same proportion as the weight of the Oyl in the Receptacle C C is diminished by its consumption.

The seventh way then is, by a Cylindrical or Prismatical Plug fitted into a Cylindrical or Prismatical Receptacle, and let down into it by a Counterpoise, hung upon a Spiral Fusey, the Oyl is so raised in that Receptacle as always to stand Brimfull, or to the same Horizontal height till the whole Oyl be consumed.

The contrivance of this way will be very easily understood by any one that shall peruse the Delineation in the eighth Figure, and examine it by this following description.

Let A A in the eighth Figure then represent a Cylindrical or Prismatical Receptacle, standing fixt upon a Table or Pedestal, from the side of which issues a hollow Arm or Branch B B, bearing the Socket for the Wick C, where the flame D is continued. Into the Cavity of this Receptacle is fitted a Cylindrical or Prismatical Plug E E, big enough to fill the whole capacity thereof, and yet not so close but that it may freely slip up and down the Cavity of the said Receptacle without sinking. Let this Plug be made considerably heavier than the Oyl of the Receptacle; that is, let the Counterpoise L, hanging upon the little Wheel M just reduce its gravity to be equal to that of the Oyl; then let the point I, where the Perpendicular toucheth the Spiral, be so far removed from the Center of the Wheel H, that the counterpoise

terpoise L may just take off its whole gravity, and suffer it to have no degree of gravity or pressure downwards. Then draw the Spiral n o p according to the direction I gave in the former way, and the effect will be produced. The Geometrical and Mechanical Demonstration of which is very plain to any one that shall consider, that, As the Plug E E by sinking into the Receptacle A A so far as to raise the Oyl to the Horizontal Superficies M M will lose its gravity by the same Degrees by which it sinketh into the Receptacle, and that is alway proportionable to the diminishing of the Oyl in the Receptacle by the flame : So the weight L will lose its power upon the Wheel H, by the same degrees by which the Plug descendeth, by reason the Line by which it is suspended becomes a Tangent to a proportionately shorter Radius of the Spiral, of the Rays of the Spiral.

I know indeed that both in this and the former Fusely there lies an objection against the true form of the Spiral, because the Line K K of the weight L doth not touch the Spiral in a point level with the Center, but in one somewhat above it, and in this latter somewhat beneath it ; but though that be a seeming material one, yet as to practice it signifies very little. For first, it will not be difficult to prove that this may be Mechanically drawn true enough, that there shall be no sensible error, and if the error be not sensible, it is no error in practical Mechanics. Next, were it the true Spiral, yet it would not be more Geometrically Delineated than this which is here required, and at best it would prove but a Mechanical approach, which is sufficient for the effect to be produced by it.

These two last contrivances do keep the flame of the Lamp always in the same place, and of the same strength and fulness. But the succeeding ways, though they maintain the flame in the same degree of strength and nourishment, yet by their motion upwards they may be made to increase, and intend the heat produced by them in the bodies posited above them, which is of great use

use in many Chymical and Philosophical Experiments.

The eighth way then is this: Make a Cylindrical or Prismatical Receptacle for the Oyl exactly like the former, with its Arm, Socket, Wick, &c. and fit into it a Cylindrical or Prismatical Plug, as in the former, that may be able to fill the said Receptacle. Fix this Plug fast into some Wall or Standard, so that it shall not be able to stir; Then by the help of two Lines fastned to a Counterpoise at one end, and, the other to the Ears of the Receptacle, so counterpoise the said Receptacle that it shall have no weight or gravity downwards, but hang in a perfect equilibrium; I say, whatever quantity of Oyl there be in the said Vessel, the Superficies thereof shall always be in the Plain which is equal to the top of the Oyl when the Vessel is filled as high as is desired, which will very plainly appear to any one that shall examine and consider well this following description, and compare it with the Delineation of the Instrument in the ninth Figure, where A A represents a Receptacle for the Oyl of any convenient capacity, made Cylindrical or Prismatical, to which is fastned a hollow Neck or Arm B B for bearing the Socket C, to which through its Cavity (being made hollow) is conveyed the Oyl or *Pabulum* for the continuance of the Flame D; into this Receptacle fit a Cylindrical or Prismatical Plug, so as it may pretty equally fill the said Cavity of the Receptacle, yet not so as any ways to hinder the sliding on upon it of the Receptacle. Let this Plug then be fixt by the top in any convenient place Perpendicularly, and setting the Receptacle underneath it, Counterpoise the same when filled up with Oyl by a Counterpoise I, which is fastned to the two strings F F F F, by which the Receptacle is to hang, which two strings for their more easie sliding to and fro move upon the two Pulleys or Truckles G G, that are fixed to the same frame to which the Plug E E is fixed; which being so adjusted, as fast as the flame D consumeth the Oyl out of the Receptacle A A, the Counter-

Counterpoise I raifeth the ſaid Receptacle on upon the Plug ſo far till the top of the Oyl be equal to the height it was at firſt counterpoised at, to which height it always keeps it till the whole be conſumed.

This laſt way of poiſing the Liquor or Oyl doth make the Superficies thereof run higher and higher as the quantity thereof is more and more conſumed, which for divers Expedients in Mechanicks, Natural Philoſophy, and Chymiſtry is of excellent uſe, as I may hereafter have opportunity to manifeſt upon many occaſions where I ſhall make uſe of them; and it would be, I fear, too tedious to the Reader to have them here enumerated.

But becauſe it may not poſſibly be ungrateful to him to have ſome uſes of this Principle here hinted, I ſhall now ſpecifie a few, and hereafter add many more, together with a great number of other Poiſes for Liquors which ſerve for very differing effects in their kinds, not leſs conſiderable, but rather ſomewhat more ſtrange, as being yet farther removed from the common practices and diſcourſes of Hydraulicks.

The firſt uſe then that I ſhall mention of this Liquor-poife ſhall be in Hydraulicks, *viz.* to make a Cifter of whatever bigneſs and depth is required to deliver all its water at the top, or ſo near unto it as it ſhall be deſired: By which means nothing of the Deſcent of the water falling into the Cifter is loſt, but without any labour or trouble the whole quantity of water that is delivered at the top into the Cifter is re-delivered again out of the Cifter at the top. This may be done by the firſt, ſecond, and ſeventh ways of poiſing Liquors; this, that, or the other, of which may be more convenient to this, that, or another effect or operation to be performed by it, which muſt be choſen and applied with judgment, according to the occaſion, and the circumſtances of it. Every of the three, though they all agree together in the producing the effect of keeping the Su-

pericies of the water to the same Level, and there delivering it, have yet each of them their several proprieties, which maketh some one of the three more proper and adapted to one design, than either of the other two, and each of the other two in some other effects and applications may be much more usefully applied than the first. By this means the whole depth of the Cistern is gained, and all that water that was used to be delivered at the bottom is now delivered at the top, and consequently gains the advantage of the Perpendicular height of the Cistern to be employed, for any use, for turning an Automaton, or conveying the Stream farther, or to a higher level.

A second effect performable by these Poises may be for delivering any quantity of water with an equal degree of swiftness, so as to continue an equal supply of water till the whole Cistern or Receptacle be emptied, the spending of the water in the Cistern not at all abating the stream without, the Counterpoise always keeping the Cistern full, and maintaining the current till the last. This may be useful for sawing or grinding stones by an Engine; for gauging of Glass Tools, or grinding glasses by an Automaton, in all which cases there is need of a constant and equal supply of water and sand; as also for washing and Fulling of Cloth; it may also serve for various sorts of Clepsydras, or measuring the quantity of time by the quantity of the current of water, as I shall by and by shew. And thirdly, for maintaining any slow and constant motion, as that of a Jack, or Clock; an Engine for continually stirring of a liquid body, or shaking, tumbling, and turning of dry Solids and powders, of which sort there are a great number of uses in Chymistry for the operations of Digestion, Calcination, Pounding, Grinding, Trituration, Searcing, and the like; which operations being certainly, evenly, and constantly performed by an Engine supplied by such a stream of water will far exceed the same kind of
of

of work done by the hands of men, especially in such operations where the Labour and Diligence is to last divers days and nights together without any intermission, which are Requisites not at all strange to Chymistry, and which will weary the diligence of the best Laborant and his Attendants.

A third effect performable by these Poises is the making a perpetual and constant stream in imitation of that of a natural Spring or Fountain in the Earth. This may be done if the Cistern be once in twenty four hours recruited and supplied with a new access of water from some Pipes, which is usual enough here in *London*, and elsewhere, where there are Waterworks and Conveyances of water. For as the wasting of the water in the Cistern does no ways abate or diminish the stream of the water from the Cistern, so the new access of other water for a supply to refill the Cistern does not at all accelerate it, but the stream remains equal; And hence, consequently constant, and, as it were, perpetual.

A fourth effect is, the delivering any quantity of water to any degree of swiftness, and the whole quantity of the water by the same degree. This is performed by tapping the Cistern at any part of the depth thereof, for according as the Vessel is tapp'd lower under the Surface, so will the motion of the water be swifter; and here the depths must be in a duplicate proportion to the Velocity desired: As for instance, the Cistern being tapped with a hole of a quarter of an Inch bore, at the depth of an Inch below the Surface, is found to deliver a certain quantity of water in a minute; if it be desired that through a Tap of the same bore there should be delivered twice that quantity, the Cistern must be tapp'd at four Inches deep; and if thrice that quantity in the same time, it must be tapp'd at nine Inches deep; and so forwards, as is already demonstrated by *Mersennus*, and other Authors. For since the pressure of Fluids upon the parts thereof increase, in the same proportion

with the depth below the Surface. And since the forces requisite to accelerate motions must always be in duplicate proportion to the Accelerations, it follows, that the perpendicular depths of the Tap under the Superficies of the water must be always in duplicate proportion to the Velocities required.

The plainness and certainty of this truth in Hydrostaticks, long since so fully and excellently demonstrated by *Stevinus* of all Fluids, and so highly improved of late in the particular applications thereof by many more modern Authors, who have writ most learnedly and clearly thereof, as well as experimentally and practically, makes me much admire at the learned Doctor *More*, who in his *Enchiridion Metaphysicum*, in the 11, 12, and 13 Chapters, and in a Book, newly published, called, *Remarks upon two late ingenious discourses*, &c. does not only deny this Gravitation in the parts of Air, but of Water, quicksilver, and other Liquors. And instead thereof, to solve the Phenomena, would introduce into the World a Principle, which he terms an *Hylarchick Spirit*, which at command acts and performs whatsoever is necessary to solve all the Phenomena of Mechanical, Hydrostatical, and, in a word, all Physical motions and effects.

In answer to whose Doctrine about Hydrostaticks I shall only urge this one Experiment of the Velocity of the current of Fluids, tapp'd and running at several depths under the Superficies of that Fluid, which can no ways be solved by the Hylarchick Spirit, and we must be fain to come to the Mechanical and plain Rules of motion, and to allow every particular of that Fluid to press with its own gravity where ever placed. And this I will prove from his own words in his *Enchiridion Metaphysicum*, pag. 113. where explaining very ingeniously the Hypothesis of Gravitation of the parts of Fluids one upon another by the similitude of six men standing in a Line, and pressing against a Wall, (which men he marks with A B C D E F, and the Wall with G) He says, that A the first man cannot press F the last against the Wall
G,

G, but by pressing B against C, and C against D, and D against E, and E against F; nor can A press B against C, nor C press D against E, nor E press F against the Wall G, but at the same time it must be understood that B presses D towards F, and D presses F towards the Wall G, for A C and E, says he, are here put for *Des Cartes Materia Cælestis*, pressing the parts of the water within the pores, and B D and F for those parts of the water pressing the bottom of the Vessel. But, says he, that B presses D, and D presses F appears from this, that casting out E and F, D doth run to the Wall G, and casting out C D E and F, B also will run to the said Wall. And so, says he, the state of the matter would be if Gravity did proceed from the meer Mechanical motion imparted to the Terrestrial parts of the Fluid by the *Materia Cælestis* of *Des Cartes*, to wit, the Elements would actually gravitate in their proper places. But since there is no such thing, it is a sure sign that Gravity doth arise from a higher cause, which higher cause he elsewhere supposes to be an Hylarchick Spirit. This from so plain reasoning is a strange Conclusion, and contrary to all experience.

Now though, I confess, I suppose Gravity to be otherwise performed than as *Des Cartes* has supposed, yet do I believe his Suppositions so Rational and Ingenious, and so much above the Objections brought against them, and so much better than any other I have yet met with, as no wise to deserve to be esteemed *fæda deliria*, as the learned Doctor is pleased to term them, pag. 125.

It shall not be my business to defend *Des Cartes* Principles at the present, nor to set up any new Hypothesis instead thereof, but only to urge this Experiment of the running of a Liquor swifter and swifter, according as the hole through which it runs is deeper and deeper placed below the Surface of the said Liquor or Fluid, and that the Velocities of those streams are always in a subduple proportion to the Altitude of the Fluid above those holes; whence it is evident, that the force that makes that Fluid run is always in the same proportion
with

with the Altitude of the fluid parts above those holes ; and consequently, that the motion of them is exactly according to the plain and obvious Rules of Mechanical motions. And consequently for the solving all the Phenomena of Hydrostaticks there is no need of any other Principles than the plain Mechanical Principles, which supposeth every Terrestrial Body to have a Gravity in it, which is always the same, and always communicates its Gravity to the Terrestrial Bodies subjected under it, and not only its own, but the Gravity of all other Bodies above it, which have communicated their Gravity to it, and that this Gravitation is always the same, and acteth continually by continual repetitions indefinitely swift. And that this gravitating or communicating of its weight, together with the weight of all other Bodies communicated to it, is no ways differing from all other communications or propagations of motion, which the Doctor must confess to be meerly Mechanical, if at least he will admit of any such thing as Mechanical motion. For I cannot conceive any Reason why the Doctor should not allow for instance the parts of a Cylinder of Lead to press upon one another as much when they are kept melted in an Iron Cylinder into a Cylindrical form part over part as when the Lead is cold and divided into several parts, and laid one over another in the same form that they were kept in by the incompassing Iron Cylinder. Since if the Iron Cylinder and melted Lead, and the Iron Cylinder and cold Lead be weighed, it will be found that they have both the same weight or gravity downwards, and do communicate continually the same force, pressure, endeavour, impetus, strength, gravity, power, motion, or whatever else you will call it to the Scale. And I suppose the Doctor will grant, that if the cold Cylinder of Lead, weighing ten pounds, be divided into ten shorter Cylinders, that are each a tenth part of the whole, and do each weigh a pound alone, every one of the upper shall gravitate upon every one of the lower ; and that the tenth, with the other nine
upon

upon it, shall press the Scale with ten pound weight; and consequently, that the tenth doth not only communicate its own gravity of one pound, but the gravity of all the other nine above it, which is nine pounds; and, if the tenth be taken away, and the ninth be put to touch the Scale, with the other eight upon it, it is certain that the ninth will not only communicate its motion, or press the Scale with its own weight of a pound, but will communicate the motion to, or press the Scale with the weight of eight pounds more, or of all the eight Cylinders superincumbent, and the like Ratiocination may be upon the eighth, seventh, sixth, fifth, fourth, and second, but the last will only press the Scale with its own weight, unless we take in the consideration of the weight of the Air, which in this Ratiocination is not necessary. Since then I think it cannot be denied but that the whole ten standing in a Cylinder one over another, the tenth is pressed by nine, and presses with ten pound weight; the ninth presses with nine, and is pressed with eight; the eighth is pressed with seven, and presses with eight, and so onwards, and that the pressure of the lowest downward is always proportionable to the height of this Cylinder. Supposing these to be all melted in an Iron Cylinder, but kept in the same position and situation, and finding the whole to keep the same weight, why should we not believe that each of those parts will exert the same effects, as to gravity, on those beneath it as the same parts cold, and in the same posture did; since if the Cylinder of the Fluid be shortned by 1, 2, 3, or 4, tenths of its height, the same abatement of weight or gravity will appear. Having seriously perused all the Ratiocination that the Doctor hath produced, both in this late Book, and in his *Enchiridion Metaphysicum*, I cannot find any convincing reason against it, but what seems grounded upon some pre-conceived Notions and Hypotheses which I cannot understand; and I cannot see how he can avoid acknowledging this to be a Mechanical motion, if at least he will allow any Mechanical

chanical motion at all, since it doth so perfectly, and in all circumstances so exactly conform and agree with the Laws of Mechanical motion, that I do not know any difference, nor any one Phenomenon of Hydrostaticks or Gravity but what may be clearly solv'd by the common Rules of Mechanicks.

But to pass by all other Mediums to prove this Gravitation or pressure of the parts of Fluids one upon another, I shall only insist upon this one Experiment of the Velocity of Fluids; vented or running at several depths below the Superficies of that Fluid. In which it is observable, that the quantity of water running within a certain space of time is always in a Subduple proportion to the height of the pressing Fluid above the hole. That is, the quantities of water are in proportion to one another as the square Roots of the several Altitudes. As for instance; it is the observation of *Merfennus* in his Hydraulicks, that a Tap of an Inch bore, four foot under the Superficies of the water will yield a pound or pint of water in 13 Seconds of time; now, if it be desired to make the water run through a Tap of the same bore twice as fast, that is, to yeild a quart or two pounds of water. This new Altitude must be made to the former Altitude, as the square of two to the square of one, that is, as four to one; whence it will follow, that the Altitude of the water above the Tap must be made sixteen foot to make the Tap run a quart of water in 13 Seconds of time. And if it be desired to have the Tap run a Gallon or eight pints in 13 Seconds, the proportion of the new Altitude to the first must be as the square of eight to the square of one, that is, as 64 to 1, whence the Altitude of the water must be 256 foot, and the like for any other quantity or Velocity desired. As if it be desired that the Tap should only run half a pint in 13 Seconds, the Tap must be placed at one foot under the Superficies, which is a quarter of the former Altitude. Now this is exactly according to the General Rule of Mechanicks. Which is, that the proportion of
the

the strength or power of moving any Body is always in a duplicate proportion of the Velocity it receives from it; that is, if any Body whatsoever be moved with one degree of Velocity, by a determinate quantity of strength, that body will require four times that strength to be moved twice as fast, and nine times the strength to be moved thrice as fast, and sixteen times the strength to be moved four times as fast, and so forwards. This is most certainly true in the motion of Bullets shot out of Cannons, Muskets, Pistols, Wind-guns, Cross-bows, Spitting-Trunks, and the like; as likewise in the motion of Arrows shot with Bows or Ballistæ; of Stones thrown by the hand, or with Slings; of Pendulums moved by Gravity or Weights; of Musical Strings; of Springs, and all other vibrating Bodies; of the motion of Wheels, Flies, &c. drawn and turned by Weights or Springs; of the motion of Perpendicularly or Obliquely falling Bodies; and in a word, of all other Mechanical and Local motions, allowance only being made for the impediment of the Air or other Fluid Medium, through which the Body is moved. Now if the Doctor will contend for an Hylarchick Spirit to perform all these, he may plausibly enough contend for it also in the Experiment of the Gravitation of the parts of Fluids one upon another.

We see then how needless it is to have recourse to an Hylarchick Spirit to perform all those things which are plainly and clearly performed by the common and known Rules of Mechanicks, which are easily to be understood and imagined, and are most obvious and clear to sense, and do not perplex our minds with unintelligible Ideas of things, which do no ways tend to knowledge and practice, but end in amazement and confusion.

For supposing the Doctor had proved there were such an Hylarchick Spirit, what were we the better or the wiser unless we also know how to rule and govern this Spirit? And that we could, like Conjurers, command this Spirit, and set it at work upon whatever we had occa-

sion for it to do. If it were a Spirit that Regulated the motion of the water in its running faster or slower, I am yet to learn by what Charm or Incantation I should be able to incite the Spirit to be less or more active, in such proportion as I had occasion for, and desired; how should I signify to it that I had occasion for a current of water that should run eight Gallons in a minute through a hole of an Inch bore? If the Doctor should tell me, that I must make the Tap at such a depth under the Superficies of the water, and then the Hylarchick Spirit will make the water run as I desire, I would then inquire how he comes to call that an Hylarchick, or matter-governing Spirit, which is rather commanded by matter, and subjected to its Laws, and is necessitated to act exactly according to the quantity and position of matter, by what means soever it be so placed? This Principle therefore at best tends to nothing but the discouraging Industry from searching into, and finding out the true causes of the Phenomena of Nature: And encourages Ignorance and Superstition by perswading nothing more can be known, and that the Spirit will do what it pleases. For if all things be done by an Hylarchick Spirit, that is, I know not what, and to be found I know not when or where, and acts all things I know not how, what should I trouble my self to enquire into that which is never to be understood, and is beyond the reach of my Faculties to comprehend? Whereas on the other side, if I understand or am informed, that these Phenomena do proceed from the quantity of matter and motion, and that the regulating and ordering of them is clearly within the power and reach of mans Industry and Invention; I have encouragement to be stirring and active in this inquiry and scrutiny, as where I have to do with matter and motion that fall under the reach of my senses, and have no need of such Rarified Notions as do exceed Imagination and the plain deductions of Reasons therefrom.

For what is clearer to be seen and tried by Experiment,

ment, and what more easie to be imagined and understood than that a Cylinder of water, or any other Homogeneous substance of twice the height should have twice the gravity or pressure: of thrice the height, thrice the pressure: of ten times the height, ten times the pressure: of 100 times the height, 100 times the pressure, and consequently, to imagine that as in all other Mechanical motion, four times the pressure will double the Velocity, nine times the pressure will treble it, sixteen times will quadruple it, and 100 times will decuple it, and so forward; So in this Experiment the same pressure will perform the same effect, and a proportionate pressure a proportionate effect. And since we find that the effect does most exactly answer the Theory (as most certainly, evidently, and undeniably it doth), why should we doubt of the cause which is so certain and Regular a Concomitant, that it is always present when the effect is performed? And where ever it is present, (if other Circumstances hinder not) the effect certainly follows. I could have gone over all the other Ratiocinations of the Doctor for an Hylarchick Spirit to perform the effects which do clearly belong to Mechanical motions and powers, and are performed and regulated exactly according to the quantity and quality of matter, and according to the general and universal Laws of motion, and not otherwise. But that is not my present business, but rather to explain how this contrivance of Pissés doth serve to make a Cistern or Vessel to run any quantity of water required in any space of time: And that to run the whole quantity either with an equal Velocity or stream, or by any desired degrees to be accelerated or retarded from the beginning to the end, which for some occasions in Mechanicks is of great use, and hath not been explained by any Writer of Hydraulicks hitherto.

I should have here left this Digression, but that I find a little further in the aforesaid Doctors *Enchiridion*, to wit, in the nineteenth Chapter, in the fifth, sixth, seventh,

and eighth Sections, continued from the 246. to the 256. Page, some Animadversions upon an Explication of Colours which I did formerly publish in my *Micrographia*, from the confutation of which he endeavours to assert this *Hylarchick Spirit*. But in this he doth *Canere triumphum ante victoriam*, and seems to make very slight of that which he neither hath hitherto by all he hath said in his *Enchiridion Metaphysicum*, nor can by all other Arguments he can produce answer. For if the Doctor had pleased to have considered the Objections I made against the Hypothesis of the Rotation of the *Cartesian Globuli*, with a little more seriousness and deliberation, he would not, I conceive, have believed that one that understood the Objection would be satisfied with so slight and insignificant answers, as he is pleased to make to them. His Answer then to the first Objection which I brought against this Hypothesis, which was raised from Experiments made with thin plated bodies, producing colours, though the refracting Superficies were parallel, is no more but this: That it is not every second Refraction of the Ray in a Parallelipiped that doth destroy the Rotation generated by the first, but only that which entring at one side, passeth through, and goeth out again with the same refraction it entered. In which case only, says he, the Rotation of the *Globuli*, generated in the first Superficies, is destroyed in the second. But, says he, a Ray falling upon a Parallelipiped, and being reflected from the second Superficies, suffers a double Refraction in the same Superficies, the one at entring, and the other at going out again; both which Refractions, says he, do promote the Rotation of the *Globuli* the same way. This he says very positively, but gives no reason for it. Nor indeed could he, since it is expressly contrary to *Des Cartes Principles*, and to all the Phenomena of such Parallel sided bodies until they come to a certain degree of thinness: For if his Affirmation were true, then must all Reflections from the Quicksilver, or foil of Looking-glasses, especially if a little oblique, make the Object spread,

spread, and become coloured in the same manner as Objects do which are look'd at through Prisms. But this is contrary both to Experience, and the Laws of Reflection; for the Refractions in the Parallelipiped B are the very same with the Refractions in the Parallelipiped A, the Reflection at D making the Ray to be refracted at F, in the same manner as if it were refracted at G by G H, and the Parallelipiped were twice as thick, and consequently the colour generated in E must be destroyed in F, and consequently produce no colours, as really it doth not in plates beyond such a thickness; whereas if the Refraction at F did promote the Rotation, as he affirms, then must the reflected Superficies I K not be Parallel to EF, but inclined to it with an Angle at L M. Then G N would represent F O, which is impossible, and contrary to the Laws of all reflection, as he might have understood if he had considered my Demonstration about the Reflections of a Globe. Nor will the Doctors adding, *Sed de hac prima objectionem non est quod sumus adeo solliciti, cum sit in materia magis incerta ac inequali cujus interna contextura videatur Globulorum motus variis modis posse mutari.* For since all transparent bodies whatsoever produce the same effect, that Subterfuge of supposing some strange invisible texture in the body of Muscovy Glass, differing from that of other transparent bodies, will prove but a lame help, for this *interna contextura* must be common to all transparent Bodies. And why it should do it at one time, and not at another, the Doctor doth no where shew, nor seems to understand.

Next, whereas in the seventh Section of the said nineteenth Chapter he says, *Verum in materia illa idonea Gutta scilicet Pluvia, si nullus Demonstrationis. Scopo subfit error, actum est de Globulis Cartesianis. Sed videtur* (says he) *ingeniosus demonstrator non satis intellexisse scopum quo collineare debeat ipse Demonstratio.* To which I answer, that I perceive by the Learned Doctors endeavours to refute it, that he neither understood that, nor the Laws of Reflection and Refraction according to

to *Des Cartes* Hypothesis. Neque enim satis erat probare (quod agnosco eum fecisse scite & eleganter) Refractiones in gutta pluvia ita fieri, ut si in duobus pellucidi Parallelipedi Lateribus oppositis, factæ essent, sed oportebat præterea evicisse quod eodem modo refringatur radius in utrisque Locis quo in Parallelipedo A refringitur, hoc est ut Radius B C quamvis oblique, perpetuo tamen curvat versus eandem extremitatem tam in F quam in D Parallelipedi A puta versus extremitatem E, nam in hoc casu Rotatio ad D dissolvitur iterum ad F. ut supra dictum est; sed Demonstratio Ingeniosi Micrographi huc non attingit; sed probat secundam refractionem in opposito Latere fieri ad modum refractionis in Parallelipedo C ubi Radius B N primo refringitur in D & procurrens versus extremitatem E ibique inflexus pergit postea versus alteram extremitatem G & Refringitur in F, quæ refractione non diluit Rotationem prioris refractionis in D, quippe quod tendentia Radii sit in partem oppositam. If the Learned Doctor had better consulted *Des Cartes* Doctrine, or the common Laws of Reflection and Refraction, he would have been of quite another mind, and would not so positively have asserted a Proposition so positively contrary to the Principles of *Des Cartes*, and all Experiments. For if what he affirms were so, then (as I urged before) according to *Des Cartes* Doctrine, and the Doctrine he would defend, the Image from a Looking-glass must be returned coloured, and the same also from a plain sided Prisme, where the refracting sides are Perpendicular or equally inclined, but contrary ways to the Reflecting Superficies. But this is contrary to Experiment, he must therefore once again consider how to find out a Reason why there is no colour generated, where, according to his Assertion, there is so great a refraction, and a doubly promoted Rotation made in both the refracting Superficies the same way, and both so much promoting the said Rotation of the Globuli. He might therefore, if he had pleased, have suspended his Conclusion. Adeo ut Doctrina Cartesiana de Globulis eorumque Rotationibus nihil periclitetur ab hac Demonstratione

tione quæ quamvis satis elegans sit & concinna, debitum tamen scopum non omnino attingit, until he had a little farther considered the nature of Reflection and Refraction. Now, because I find that the Learned Doctor is not the only person that hath not rightly apprehended this Theory, give me leave to explain a little more particularly the manner thereof: Suppose we then in the three Figures D E and F, that the space between the two Parallel Lines a c and b d doth represent a Ray or Radiation of light; Not a Mathematical Line, but a Physical one of some Latitude, between which Lines is propagated a motion, or something equivalent thereunto, which serves to produce the effect of light. This motion we suppose to be propagated by a Pulse or Wave in all uncoloured Rays at Right Angles with the Line of Direction, but in coloured Rays more or less obliquely according to the greater or less refraction. We will suppose the stroke of the Pulse to be the length of the space between 1 and 2, or 2 and 3, or 3 and 4, &c. and consequently, in a uniform medium the pulse will continue the same, and the expansion of it will be Perpendicular to the Line of Direction or progress; but when it comes to the Refracting Superficies c d, Obliquely the side of the Pulse c touches the refracting Superficies first, and being propagated into the refracting medium by a longer and quicker Pulse, it is propagated to 4 below c before the other side of the Pulse touches the Superficies at d, the Pulse therefore 4 4, 5 5, 6 6, &c. becomes Oblique to the tendency of the Radiation; and by the Superficies e f it is reflected by 7 7, 7 7, 7 7, till it touches the second refracting Superficies g h; where it is observable, that the same side of the Ray that entred first the Superficies c d enters first into the Superficies g h, in the same manner as if it had proceeded on by the straight Lines f m e l till it met with a Parallel Superficies l m to the first c d; for the Ray between the two Parallel Lines f h, e g, hath the same inclination and respect to the Refracting Superficies h g, that the Ray between f m and e l would have

have to the Superficies m l, supposing there were no Reflecting Superficies at e f. I shall not need, I hope, more particularly to demonstrate every part of this Explanation, the very observing the Delineation of the Scheme being enough to make it plain to any one never so little versed in Geometry, from which he will plainly perceive that what I endeavour to demonstrate was really so, and that I did understand what scope my Demonstration aimed at, so far as to hit the Mark, which was to shew that Colours were generated, where, according to *Des Cartes* own Principles, there could be no Rotation of the Globuli. Now, though the Learned Doctor would not admit of this Demonstration to be sufficient to do the work, yet he says, *Pag. 252. Veruntamen dissimulandum non est, non pauca me meapte opera excogitasse quibus pro persuasissimo habeo eorum motus & rotationes modis pure mechanicis semper fieri non posse.* And in prosecution of the destruction of this Rotation of the Globuli, which he hath hitherto seemed to defend, he adds four several Arguments, I shall not now stay to repeat them. But whosoever will please to read what the Learned Doctor hath *suapte opera* excogitated against the *Cartesian Hypothesis*, and set down in the 252, 253, 254, and 255. pages. And compare them with what I have said in the forementioned place, to wit, at the latter end of the 60. and the beginning of the 61. pages of my *Micrographia*, may plainly find the Arguments brought by the Doctor do very little, if at all, differ from those I there published.

I could heartily therefore have wished that the Learned Doctor had made use of some other Mediums to prove the Existence of an Hylarchick Spirit, and not have meddled with Arguments drawn either from Mechanicks or Opticks; for I doubt, that such as understand those subjects well, will plainly see that there is no need of any such Hylarchick Spirit; and if there be no need of it, but that all the Phenomena may be done without it, then it is probable that there is none there, for

Natura

Natura nihil agit frustra. It had been much easier to have proved the existence of it by Arguments drawn from subjects we less perfectly understand, as from the generation, nutrition, vegetation, and propagating of Vegetables, and animal substances; for there the manner of the progress of Nature being infinitely more curious and abstruse, and further removed beyond the reach of our senses and understandings, one may more boldly assert strange things of this Hylarchick Spirit without fear of controul or contradiction, and from whence possibly it may never lie within the power of Reasoning to banish him.

But to leave this Digression, and return to the use of these water-pouises.

A fifth effect may be for washing and refining of Earth, Clays, Powders, and the like; the clear water by these contrivances being made to run over gently at the top, and so leaving all the settlement from the water at the bottom.

By any one of these, with a receptacle Cistern added to it, the stream of water from that Cistern may be accelerated or retarded by any degrees desirable. This doth depend partly from the proportion of the Tap of the Receptacle Cistern to the Tap of the counterpoised Cistern, and partly from the shape and make of the Receptacle Cistern, by the proportion and shape of which the stream of Liquor through the Tap of the Receptacle Cistern may be modulated at pleasure, as any one, a little versed in Hydrostaticks, will easily perceive and demonstrate.

A sixth effect may be for governing the heat of Lamps for Distillations, Digestions, Fermentations, Putrefactions, Dissolutions, hatching the Eggs of Birds or Insects; accelerating, and seasoning, or timing the growth of Plants; nealing of Glasses and Metals by the gradual access of the heat, so as to make them fit for stronger
G. degrees,

degrees, or by the gradual receſſto bring them out of the greater degrees to make them tough and capable to receive the cold of the Air.

It would be too long to give inſtances of contrivances for every of theſe operations but the ſkilful Mechanift, Philoſopher or Chymiſt will eaſily ſupply his own deſires by ſome one of theſe I have inſtanced in, or at leaſt by a compoſition of them. I ſhall therefore only add a deſcription of a Clepſydra or time-keeper or two, and ſo leave this ſubject for the preſent.

A deſcription of a new ſort of Clepſydra.

THIS contrivance is nothing elſe than that Two of the ſecond ſort of Veſſels are ſo contrived as to run into each other and to empty themſelves and be filled alternately, and their bigneſs or capacity and the hole through which the Liquor is vented are ſo proportioned as to be emptying the ſpace of an hour, which is eaſie enough, and may be adjusted to what accuratenefs is deſired. Then the convex Superficies of the Cylindrical poiſe is divided into ſixty equal parts by ſtraight Lines drawn upon its Surface Parallel to the Axis, and to each other; theſe lines by the ſinking or turning of the ſaid poiſe denote the minutes, and if ſmaller Diviſions of time be deſired, the ſpaces between them may be divided by other ſmaller Parallel Lines denoting the parts of each minute to what niceneſs is deſired. One of theſe Cylindrical Receptacles may be fixt, and the other by an eaſie apparatus may be made to riſe a little when it is top-full, and fall a little when quite empty below the Level of the other that is fixt: The Chanel between them, through which the water is to run out of the one into the other, may be a ſmall pipe with a hole in it of a bigneſs proportioned, as I ſaid above, to let the Liquor run out of

of one into the other in the time desired, and its ends may be fastned to the two Receptacles by a part of the neck of a bladder or gut, so that it may be limber, and may always have a Declivity into the Vessel that is to be filled; the Declivity need not be above half an Inch. The Liquor used in it may be Water, Oyl, or any other Liquor that doth not easily evaporate: But the best of all is Quicksilver, because it doth not with keeping evaporate at all sensibly, which I have carefully observed for these fifteen years last past. Nor doth it grow thick or foul by the alteration of the Air, nor do I find it sensibly alter by the heat and cold, at least not comparable to the great changes which other Liquors suffer by the alterations of those qualities. It is an excellent material for measuring time in a standing Machine; and there may be hundred of ways contrived to make it measure the space thereof as accurately as a Pendulum; and I have many times admired that *Tycho Brahe*, who was otherwise so curious and exact in the contrivance and make of his Engines and Instruments, was yet so defective in his contrivances of measuring time by Quicksilver, when there were so many obvious and easie ways of doing it, as he seems to complain in his works. I have made trial of several with very good success, and found some of them even beyond expectation certain, of which I may hereafter upon an other occasion add the descriptions, when I publish the various ways of making exact Time-keepers or Watches. In the mean time, being now speaking of Time-keepers, for variety sake I shall mention.

A New Principle for Watches.

THIS is a way of regulating both standing Watches, and movable Watches, either for the Sea, or the Pocket, which some ten or twelve years since I shewed the *Royal Society*, when I shewed them my contrivances of the Circular

lar Pendulum, which is since published by Monsieur *Hugenius*, which is also mentioned in the History of the said *Society*, p. 247. lin. 20. This was by a fly moving Circularly instead of a ballance, whose motion was regulated by weights, flying further and further from the Center according as the strength of the Spring of the Watch had more and more force upon its Arbor. The Weights were regulated from flying out further than they ought to do by the contrivance of a Spiral Spring, drawing both the said Weights to the Center of the motion or fly, in the same proportion as I then demonstrated Gravity to attract the weight of a Circular Pendulum, moved in a Parabolical Superficies, towards the Center or Axis of its motion. The Weights were so contrived as always to counterpoise each other. The Skeleton of this fly you have represented in the Figure. The particular explanation of the parts, and the Geometrical Demonstration of the Principle both of the Springs, and of the flying from the Center, I shall explain in the Theory of Springs, and in the description of Time-keepers and Watches.

Οἱ δημιουργοὶ κατασκευάζουσιν ὄργανον κρῖνοντες τὴν ἀρχὴν, ὅπως ἢ τὰ μηχανήματα. φανερόν μόνον τὸ δαυμασόν, πὸ δ' αἴτιον, ἀδελον. *Arist. Quest. Mechan.*

An Observation about the Seed of Moss.

Since the publishing of my Micrography, I have met with an Observation, which though it be of one of the smallest compound bodies I have hitherto taken notice of, yet does it afford a hint of very great concern in Natural Philosophy; And it does seem to make clear the cause of a Phenomenon, that hath appeared dubious, not only to me, but to many other more knowing Naturalists. I have often doubted, I confess, whether Moss, Mushrooms, and several other small Plants (which the Earth seems to produce

duce *ἀντιμύκτων*) were the off-spring of a Seed or Grain; and I have been apt to believe, that they were rather a secondary production of Nature; being somewhat the more inclined to that opinion, because having formerly examined the small knots or Seed-cods of Moss with a single Microscope, I could not perceive any thing in them that I could imagine to be Seed, at least not so great a quantity as seemed necessary to maintain so numerous a Progeny, as was every where to be found of it; that, which then came out of them, seeming to be rather a pulp or pith, than any thing like the Seeds in other similar Cods. But being since somewhat more inquisitive, I did examine several of the above-mentioned Knobs or Seed-vessels, and found that there were seeds in them, no less wonderful for the greatness of number, than the smallness of bulk. Taking then some of the ripe and brown or reddish ones of them, and pressing them pretty hard, I found, that there was a small dust went out of them, which seemed to vanish into the Air. Pressing and squeezing others of these upon a black plate, and examining the powder with a Microscope, I found it to be a great heap of exceeding small Seeds, Globular, and pretty transparent. It is the smallest, I confess, I have yet seen; and, it may be; that has hitherto been discovered. And, unless that be a plant, which I discovered growing on the blighted leaves of Roses, and that those small bodies be seed vessels; or, unless those Knobs, I have discovered on the top of mould, be the like; I cannot presently imagine where there should be found a smaller. For, I find, that there will need no less than thirty six hundred of them to be laid one by another in a line, to make the length of an Inch; and, to cover the Superficies of an Inch-square, there will need no less than nine hundred and threescore thousands, besides twelve millions, of single Seeds if laid quadrangularly, but if laid triangularly, there will need no less than two hundred and fourscore thousand, besides seventeen Millions, of single grains. And the number in a grain weight of them cannot be less.

less than one thousand three hundred eighty two Millions and four hundred thousand single grains, about eighty of these square Superficies of Seeds being laid one upon another in the Trigonal order, making, as near as I can guess, the thickness of a piece of fine Paper, a square Inch of which weigheth a grain. And though this may seem a most incredible narration; yet I would desire such as are apt to be too censorious, to take the pains to gather a few of these Seed-vessels, and examine them as I have done, and then speak what they find, and believe no more than their own sense and reason will inform them, and they may easily see, that what I have asserted, will be rather short of than exceed the real numbers. Now if this Shell of the Seed be thus small, how much smaller must needs be the rudiment of the Plant that lies enclosed within it? And how easily may such Seeds be drawn up into the Air, and carried from place and place, even to the tops of the highest Towers, or to places most remote, and be sowed by the passing Air, or falling drops of Rain, on the boughs or branches of Trees, sides and tops of Walls, Houses, or Steeples? And it is not in the Art of man to leave Earth exposed to the common Air, and to exclude the entrance, or prevent the sowing of these imperceptible Seeds; and therefore it is not to be wondered at, that, if any earth, though never so pure, be exposed to the Air and Rain, though at the top of a Steeple, it will produce Moss.

Further inquiry may possibly instruct us, that there may be Seeds of Mushrooms, Mould and other Vegetables of as small, if not smaller, bulk, which may be dispersed and mingled with the Air, and carried to and fro with it, till washed down by the falling drops of Dews or Rains; which, if they chance to light on a convenient soyl, do there Vegetate and spring up; but dye and perish, if the ground, they light on, be not natural and agreeable. But whether this conjecture hit right, further observation must determine.

This

This discovery I made the year after the late Fire of London, to wit, in the year 1667. there being then vast quantities of it to be found every where dispersed among the Ruines left by that Fire, which made me, I confess, very much wonder at first how such vast quantities should come to be then so suddenly rooted, and was the occasion of my more strict examination of it. This I presently shewed to many of my Acquaintants, and the next year 1668. upon the eleventh of *June* I brought an account of it into the *Royal Society*, where I suppose it may yet remain upon their Register; and it was not a little surprising to all that saw it, when they considered how exceedingly small each particular Seed was, and yet how infinitely vast the number of them was produced by each Plant. How prodigiously small the first beginning and rudiment of that Plant must be that was produced by it; now, though indeed the Plant it self be one of the smallest, yet this Seed of it was much smaller in comparison to the Plant than the Seeds of most other Plants compared with theirs. But about two years after this I received from a very good friend of mine at *Bristol*, the Ingenious and Inquisitive Mr. *W.C.* a Relation of some later discoveries of his, which seemed much to outstrip even this, whether the comparative magnitude of the Plant, and of the Seeds, or the number of the Seeds, or the curiosity of the Seed-boxes, or the strange way of sowing and dispersing, or the place and manner of the Seeds production be considered. As they were sent to me by him in a Letter from *Bristol*, dated *September 30. 1669.* take them in his own words and description.

Notwithstanding my many other Avocations, variety of discoveries do almost every day enlarge my experience; but more especially this last Week I was very happy in the detecting of that which all the Philosophers and Physicians of former Ages, have been ignorant of, as we may well imagine from what remains we have of them. My Discovery in short was this, that all the kinds or species of Ferns together with

with all the like Capillary Plants their Congeners are (though generally denied to have any at all) more abundantly prolific in Seeds than any other Plant beside, especially the common Female Ferns or Brakes, and those more elegantly formed (I mean chiefly in the little Vesicles containing the Seed) than many others, among the hundreds I have observed. To make it demonstrable to you, I have now sent you both the Plants with the Seeds on them, and the Seeds of the same Plants apart in Papers by themselves, which I took off from other Plants of the same kind, having plentiful parcels of each (excepting of what I have not sent you) this being the season of perfecting their Seeds. I thought to have sent you draughts of the Seed Vessels, as they appeared presently after gathering, but could not. I presume some of the Vesicles or little boxes may remain whole, so that by your Microscope you may see their true figures and distinctions, some of them being more flattened on each side the little ring or embossed girdle encompassing them, others more swelling.

Also those little rings or bands encompassing the boxes are different, in some of the kinds broader and flatter, in others rounder, and standing up higher, yet all agreeing in the principal parts of their form. I purpose to draw the figures of them all as they appear by the Microscope, together with their Seeds, and to add descriptions of all circumstances considerable, and joyn them to the rest of my draughts of that kind. Some particulars most considerable I now give you in the following account.

1. The little boxes containing the Seeds are in most of these Plants not half, and in some not above one third, or one quarter as big as a very small grain of common white sand; appearing like little bladders infolded with rings or bands, shaped like certain little worms I have met with, which may be referred to the *Teredo's* and *Erucæ's*.

2. As near as I could compute, some of these bladders contained about 100 Seeds, which were so exceeding small, as to be wholly invisible to the naked eye, and indiscernable without a Microscope.

3. The

3. The Leaves of both the Ferns, especially the common Female Fern, (which is more abundantly stored with Seed than any of the rest) and the other I now send you, being kept close without bruising, and soon after gathering exposed to the Sun, or dry Air, the bands of as many of them as are ripe, will contract themselves and break, and sling their Seeds all about, after the same manner as some other small Plants, such as the *Perficaria Siliquata*, and some of the *Cardaminas* are observed to do. This I have observed with a single convex glass as well as with the Microscope, but with the latter only I could discover the falling of the Seed. And a pretty quantity of the Seed being rubbed or brushed off from the Leaves upon a fine piece of Paper or Parchment, and swept together into a heap, many of those boxes breaking together, and jostling one another would make the heap seem, as it were, full of Mites or living Creatures, even to the bare eye; and if the place be free from noise, and the Ear be close applied, the crackling of them upon breaking may easily enough be heard, and upon running over the Paper with a Microscope the Seeds will be found dispersed, and thrown at a great distance.

4. The figures of the Seed-vessels, as also of the Seeds of all the Ferns and those their Congeners, called Capillary Plants, are very near of the same shape and size, notwithstanding the vast disproportion between them, as particular common Fern, Wall-Rue, Harts Tongue, and Osmond Royal, the first three of which being very remarkable for their unlikeness to each other, and the last chiefly for its excelling so many thousand times in magnitude that of Wall Rue. Which observations may seem to confirm the opinions of some learned Botanists that the affinity of Plants are to be judged by the figures of their Seeds.

5. That Osmond Royal, which excelleth all the other Ferns both in greatness, comeliness, and vertues, and which hath been accounted barren, with the rest hath Vessels and Seeds of the same figure with the other, and very near of the same size, the extreme smalness of which, even to invisibility, and the greatness of the Plant, one root whereof, with all the growth out of it, I have found weighing ten pounds and bet-

ter, is surpassingly more wonderful than that of Moss Seeds; of which I have some kinds of them bearing Seeds, that a great number of them, with their Roots, Stalks, Leaves, and Seeds, do not weigh a Grain. Besides, I have found of the common Female Fern some which have been from the Roots to the utmost top of the Leaf nine foot high, and within these three days measured the common broad-leaved Male Fern six foot and an half long; some of the Leaves, of which are among those I now send you.

6. But that which appeared most admirable, both to me and some other Gentlemen that were witnesses of it with me, was the many differing kinds of small living Creatures, wholly invisible to the naked eye, and even through largely magnifying spectacles, though some of them were to be seen through a deep Convex glass; but with a Microscope, when the Plant was newly gathered, they might be seen nimbly running up and down among the Seed-vessels, and some of them were so small as not to be above twice as big as the small Seeds in the bladders; a description of some of which I may hereafter send you.

I have inclosed in the box sent you twelve sorts of Plants of this tribe, being the greatest part of the number, and only seven sorts of the Seeds; those wanting are the Cetrach, Wall Rue, Maiden-hair, and Polypody, of which notwithstanding you may satisfy your self in the mean time till I can send them green by those small parcels of the Plants which you will find amongst the rest, though by keeping they are withered.

The Seeds of the Ferns through a very excellent Microscope appeared of the bigness of a small Vetch or Seed of Lentils to the naked eye, and some of them shrink like the sides of white Pease, with small regular knobs and hollows. Those of Polypody are differing in colour and shape being yellowish, as the others are brown, red, and formed like the Seeds of the smaller Medicas that is of a Kidney shape. All the rest I found very near of the same form. I cannot omit what I observed in Cetrach, which Plant I have heretofore often considered, and wondred at the ill-favoured roughness on the under

der side of the Leaf, appearing like the fleshy side of tann'd Leather, being wholly ignorant what Nature meant in it, but now by my Microscope I find it a very pleasant object differing from all the rest, wherein the curiosity of Nature (in a Plant so abject as that appears) is shewn beyond imagination. This, when fresh gathered, and not bruised, appears through the Microscope like fine thin Membranes, such as the Wings of Flies, chequered with figures after the manner of Honeycombs when the cells are full of honey, and closed with Membranes, amongst which, as in so many Cells, lie the Seed-vessels, shaped as before is mentioned. I doubt not but you have read the strange stories and fabulous conceits of Authors about Fern Seeds. But Parkinson is more Orthodox in some things than any of them : For he positively concludes from Gen. I. 11, 12. that all Plants have their Seeds, and consequently Fern ; where if he had staid, he had asserted a general truth : But in coming to particulars, he affirms as great an untruth, in saying, fol. 1036, and 1037. that the Seed is ripe at Midsummer, according to the old traditional Fable, and tells how it may be gathered ; whereas now is the very season of their seeding, and at Midsummer this and the rest are not come to their full growth, before which no Plant seeds. That dustiness which he speaks of, and calls the Seed, is no other than what is found on divers other Plants, being an irregular Dust, and is not found on the borders of the dents of the Leaves on the under side, on which the Seed grows, but all over sprinkled on both sides, and not found when it is fully grown. This he affirms of the Male Ferns, which are all differing very notably from the common Female Fern, concerning which the fabulous tradition is held. But after in the following Chapter of the Ferns and their Relatives now sent you, he seems to give over his Scripture Proposition, and, speaking of the Seeds, says no more but that they have spots, dashes, scales, or marks on their back-sides. And of the Osmund Royal (speaking of the bush at the top of the Plant) says it is accounted as the Flower and Seeds. And of the *Lochitis aspera* says plainly they have none at all. Of this last I am yet to enquire, but doubt not I shall find that it hath

Seed like the rest. Of all which Gerrard and Johnson his Corrigitor gravely concludes (having indeed no demonstrable ground to the contrary) that some have been too rash in affirming Ferns to have Seed. I intend next Summer to observe whether these hitherto unknown Seeding Plants have Flowers. In the mean time I am, &c.

Bristol. Septem-
ber 30. 1669.

W. C.

Maculae in Sole.

DURING this last great heat of weather in June I observed a very conspicuous Macula with its immediatly incompassing Nubecula, and some other less conspicuous Spots at a further distance pass over the Disk of the Sun, and found that it was nearest the middle when the heat was greatest, that the heat increased as it came nearer the middle, and decreased as it departed from it. It may be therefore worth observing for the future whether the like weather do not happen upon the next appearance of the like Macula, since it seems not very improbable to suppose that the body of the Sun it self may be much hotter when such eruptions appear, those Maculae often times ending in Faculae. And the rather because I am informed that this extraordinary heat hath not been peculiar only to *England*, but very general to *Europe*; what it hath been to other parts of the world further intelligence will inform us.

Upon a second appearance of Spots in the Disk of the Sun at the latter end of *July* and the beginning of *August*, when at one time, to wit, *July 29.* there appeared about six greater and smaller in one knot with their proper Nubecules or Umbra's, the heat of the weather again increased to a very great degree, and abated as they drew toward the Limb, and grew fainter. But it hath now since the disappearing, *viz.* on the fourth of *August*, been exceeding hot also, though I do not find any Spots this seventh of *August*; it may therefore possibly be that other parts of the body of the Sun may have an extraordinary inflammation

inflammation which may cause so fervent and lasting heats as have hapned this Summer. At least this Hint may deserve some farther Inquiry, for though probably it may not be attained to predict the appearances of those Spots, yet possibly the appearances of the Spots may serve to predict the future constitution of the weather. At least it seems worthy remarking that the greatest heat that hath been in the Air this year was on that day of *June* when the first Spot was near the middle of the Sun.

P O S T S C R I P T.

THe Publisher of Transactions in that of *October* 1675. indeavours to cover former injuries done me by accumulating new ones, and this with so much passion as with integrity to lay by discretion; otherwise he would not have affirmed, that it was as certain that none of my Watches succeeded, as it was that I had made them several years ago : For how could he be sure of a Negative? Whom I have not acquainted with my Inventions, since I looked on him as one that made a trade of Intelligence.

Next whereas he says I made them without publishing them to the world *in Print*, he prevaricates, and would have it believed that they were not published to the world, though they were publickly read of in Sir *John Cutlers* Lectures before great numbers at several times, and though they were made and shewn to thousands both English and Foreigners, and writ of to several persons absent, and though they were in the year 1665. in the History of the *Royal Society* published to the world in Print, because, forsooth, they were not printed in his Transactions.

Thirdly, whereas the Publisher of Transactions makes a long story of my seeing his Journal *De scavans*, and my desiring to transcribe that part of it which concerned this matter, as if I had requested some singular favour thereby. I answer,

First,

First, that he knew I designed presently to have printed it with Animadversions, but he endeavoured to prevent me, designing first clancularly to get a Patent of it for himself, and thereby to defraud me.

Next, I say, I had a right without his favour to have seen, perused, and copied it, as I was one of the *Royal Society*, the intelligence hethere brings in being the *Societies*.

Then it is denied that the Describer of Helioscopes well knew that the Transcriber of Intelligence would publish it in his Transactions, though it was believed if the publishing it would injure me it would not be long concealed; which was the sole reason of Printing in the same Transactions, viz. 112. a Letter which he had several years before.

Thirdly, Whereas he asserts that several discoveries of the Accuser had been vindicated from the usurpation of others. It is answered, the clean contrary is upon good grounds suspected from the Publication of a Book about Earthquakes, Petrifications, &c. Translated and Printed by H. O. the manner of doing which is too long for this place. Such ways this mis-informer hath of vindicating discoveries from the usurpation of others.

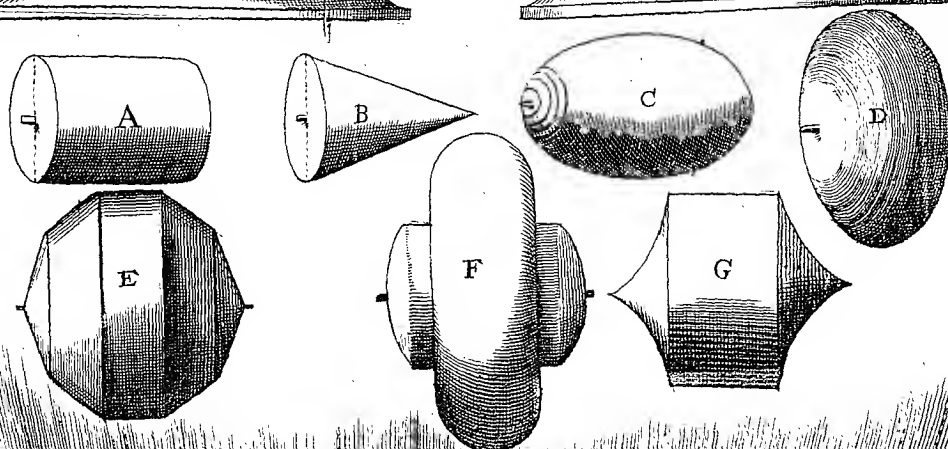
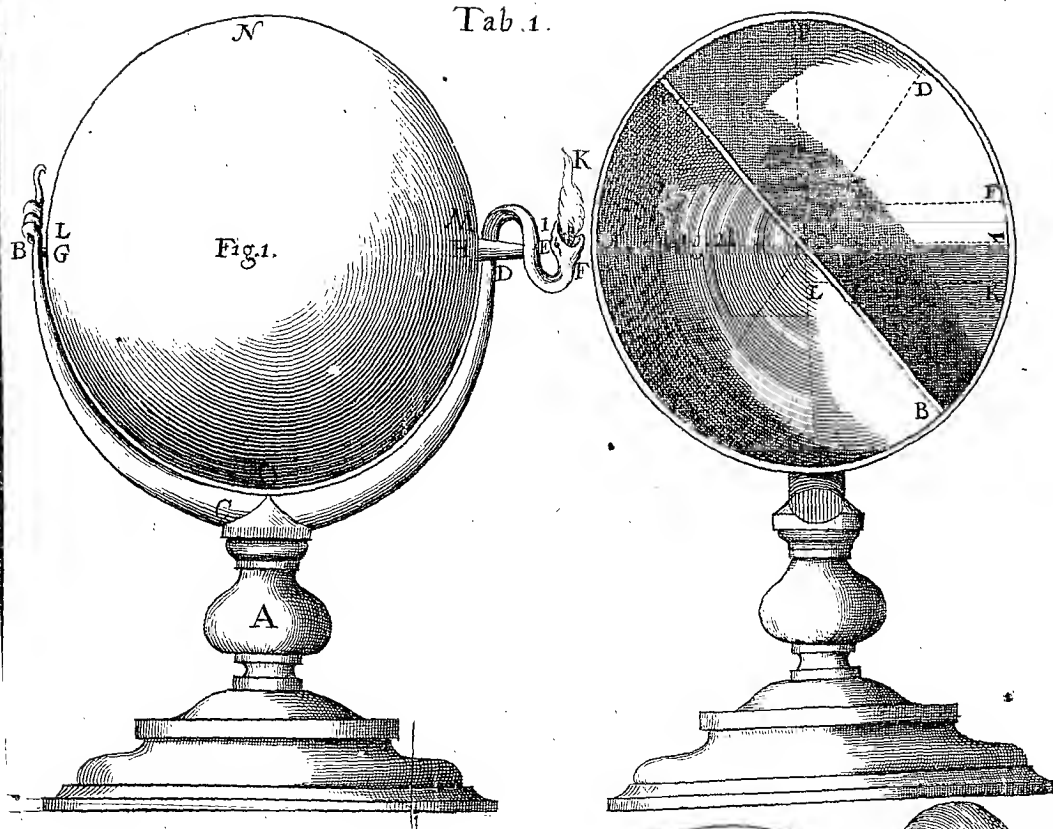
To his upbraiding me with his having published some things of Mine; I answer, he hath so, but not so much with mine as with his own desire, and if he send me what I think worth publishing I will do as much for him, and repay him in his own coyn.

Lastly, Whereas he makes use of We and Us ambiguously, it is desired he would explain whether he means the *Royal Society*, or the Pluralities of himself. If the former, it is not so, as I can prove by many Witnesses; if the later, I neither know what he is acquainted with, or what has been imparted or explained to him.

So not designing to trouble my self any further with him, unless he gives me occasion, I dismiss him with his

——— *Speque metuque*
Procul hinc procul ito. Ho.

Tab. 1.



Tab. 2.

